Competitive Liner Shipping Network Design

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Competitive Liner Shipping Network Design

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Containerized transportation – challenges and opportunities

The liner shipping industry has made maritime transportation the backbone of the modern global trading system. Liner vessels, which make transporting goods among countries feasible, are responsible for moving approximately 60% of global goods in terms of value. Reliance on liner shipping to transport goods internationally is only expected to increase due to its economic and environmental advantages compared to other transportation modes. Consequently, operational improvements and optimization of ship design are more important than ever.

Optimal route networks

Well-designed route networks can decrease fuel consumption substantially, thus positively impacting the environment and the competitiveness of liner companies. Today, networks are designed manually. By evaluating the design problem as an operations research problem, improvements can likely be achieved. Even small improvements to existing global networks can significantly impact the environmental, as more than 0.5% of annual CO_2 emissions are produced by container ships.

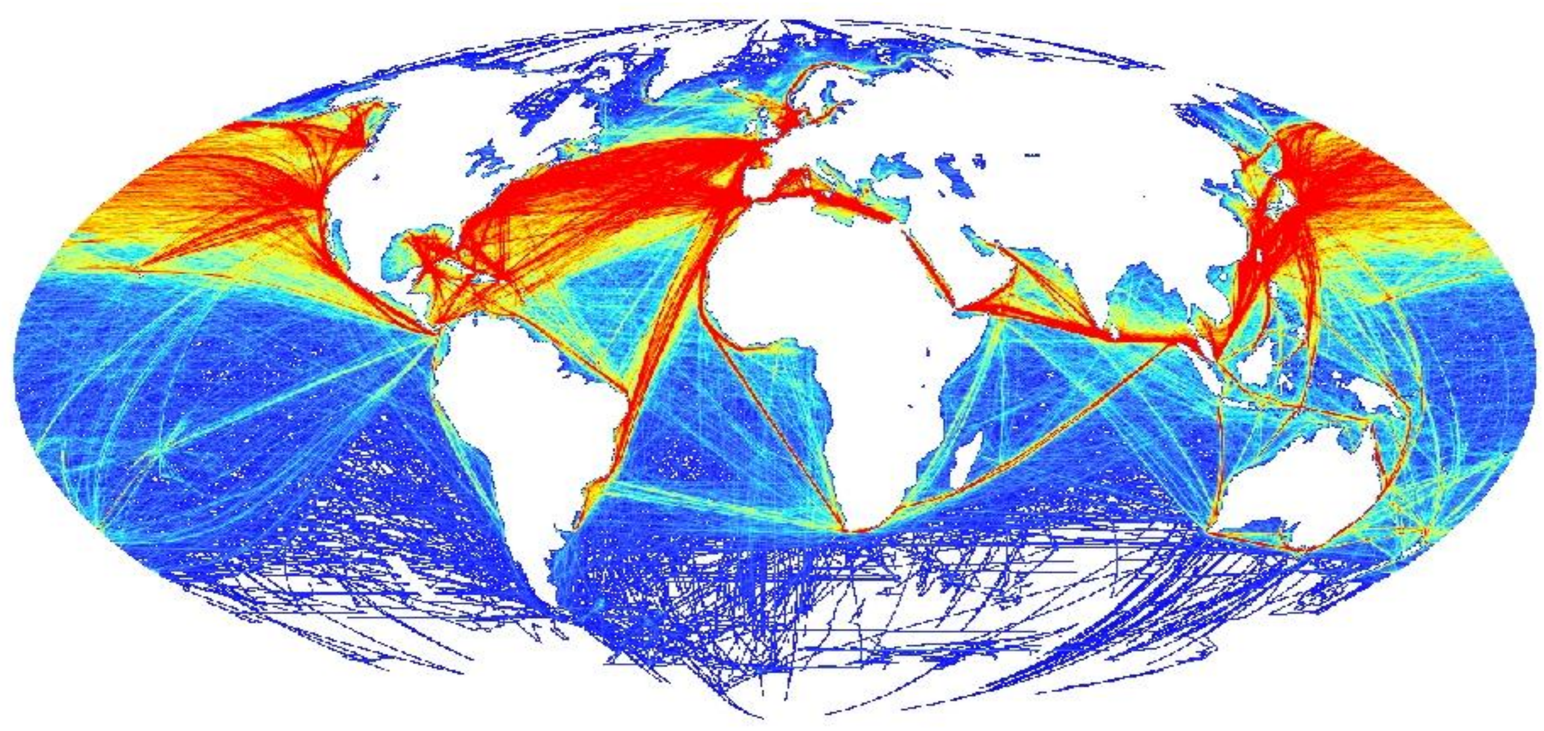
Problem complexity

Liner shipping networks have several distinct characteristics not shared by other transportation modes, with the size and complexity of liner shipping adding further challenges. Heuristic as well as mathematical methods have been proposed, but all have limitations when scaling to real-world global networks.

Problem Characteristics & Available Data

The liner shipping network design problem is to determine the best set of sailing routes for a given fleet of vessels to transport multiple commodities. Sailing routes are given by a set of ports serviced at a certain frequency, the deployed vessel class, the number of vessels, and the sailing speed of these vessels. This is done while satisfying a given global demand of containers. A mathematical formulation of the problem should comply with:

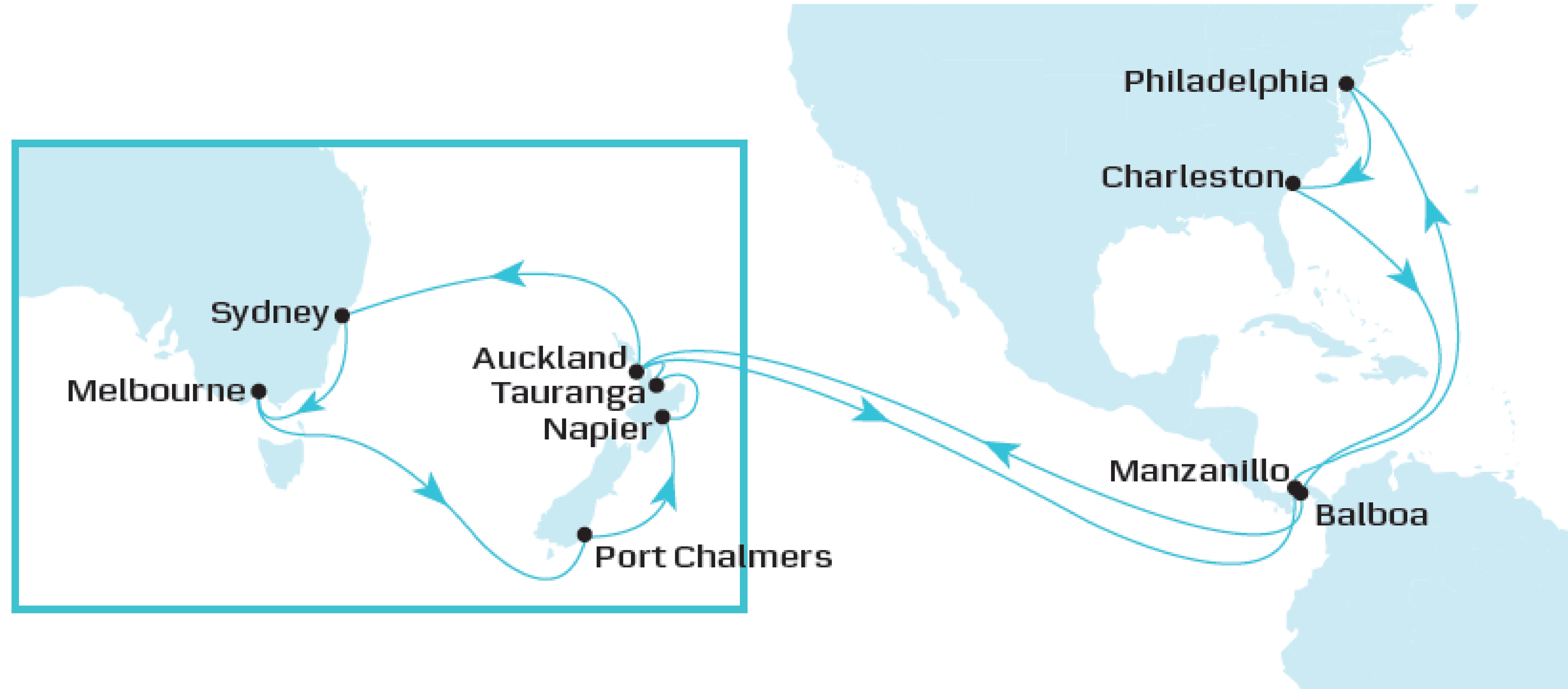
- Specific frequency requirements
- Non-simple cyclic services
- Level of service is crucial (in particular transit times[1])
- Transshipments of containers are allowed at a cost
- Split pickup and delivery, but no depots (as in VRP)
- Public available library with several data instances[2]



Current research and perspectives

We are investigating network flow models that explicitly consider the level of service. This can be done by imposing a maximum allowed transit time for containers or by limiting the number of allowed transshipments (i.e. how many times a container can change liner ships before reaching its destination).

As networks are limited in flexibility and the planning process requires manual decisions, we pursue formulations that can serve as decision support tools. Ideally these formulations can be used at the strategic, tactical, and operational level by modern liner shipping companies to reduce emissions and cost.



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[1] Karsten et al; An analysis of time constraints in the liner shipping network design multi commodity flow problem; in preparation
[2] http://www.linerlib.org/